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(54) **DIRECT CONVERSION RF TRANSCEIVER FOR WIRELESS COMMUNICATIONS**

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**Related U.S. Application Data**

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**H03K 9/00** (2006.01)  
**H04L 27/06** (2006.01)

(52) **U.S. Cl.** ..... **375/316; 375/344; 375/219; 455/130; 455/192.2**

(58) **Field of Classification Search** ..... **375/219, 375/316, 324, 344, 345, 346; 455/130, 192.2**  
See application file for complete search history.

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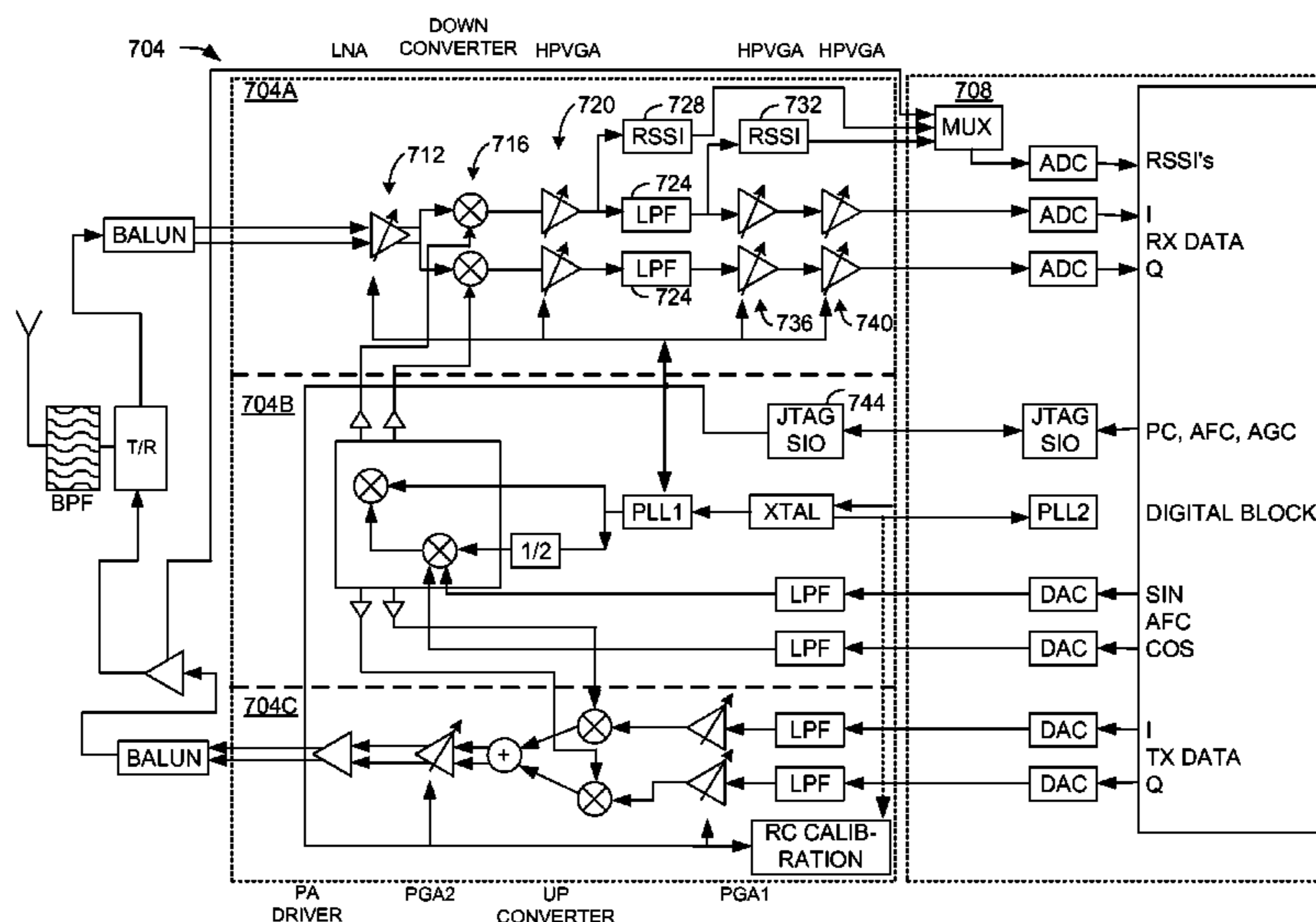
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(57) **ABSTRACT**

A single chip radio transceiver includes circuitry that enables received wideband RF signals to be down converted to base band frequencies and base band signals to be up converted to wideband RF signals prior to transmission without requiring conversion to an intermediate frequency. The circuitry includes a low noise amplifier, automatic frequency control circuitry for aligning the LO frequency with the frequency of the received RF signals, signal power measuring circuitry for measuring the signal to signal and power ratio and for adjusting frontal and rear amplification stages accordingly, and finally, filtering circuitry to filter high and low frequency interfering signals including DC offset.

**20 Claims, 8 Drawing Sheets**



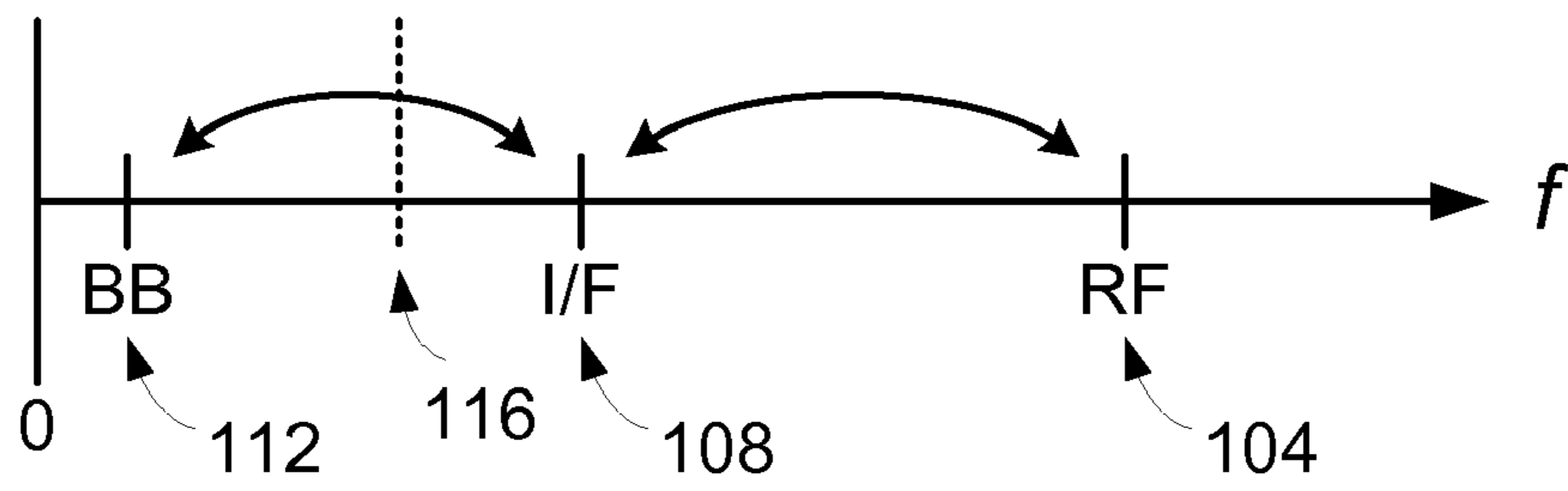


FIG. 1A

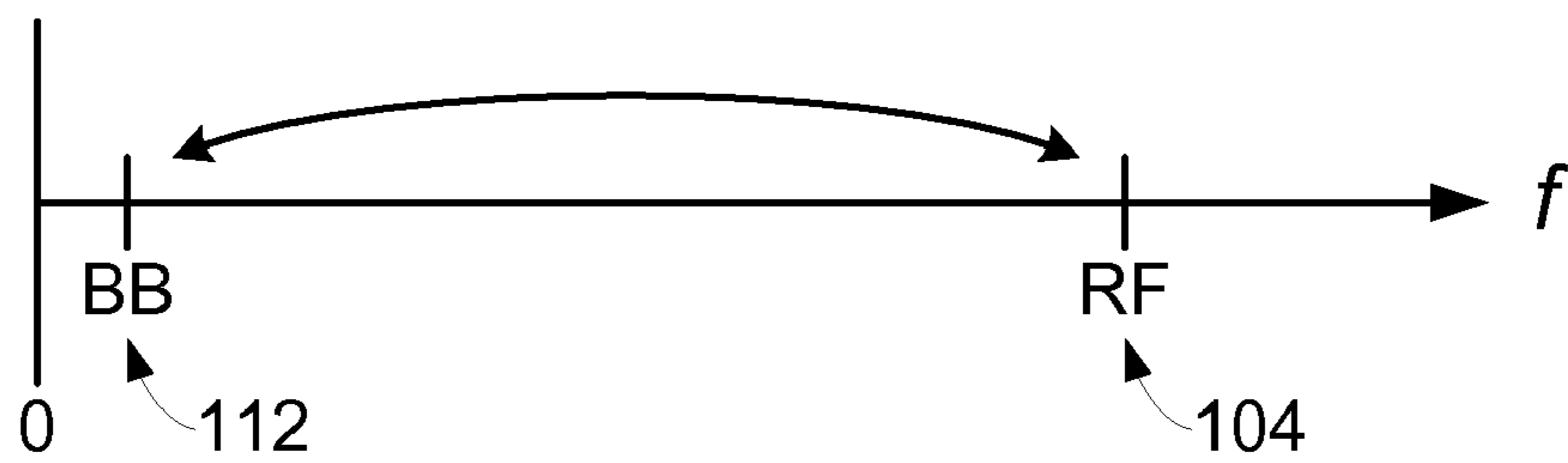


FIG. 1B

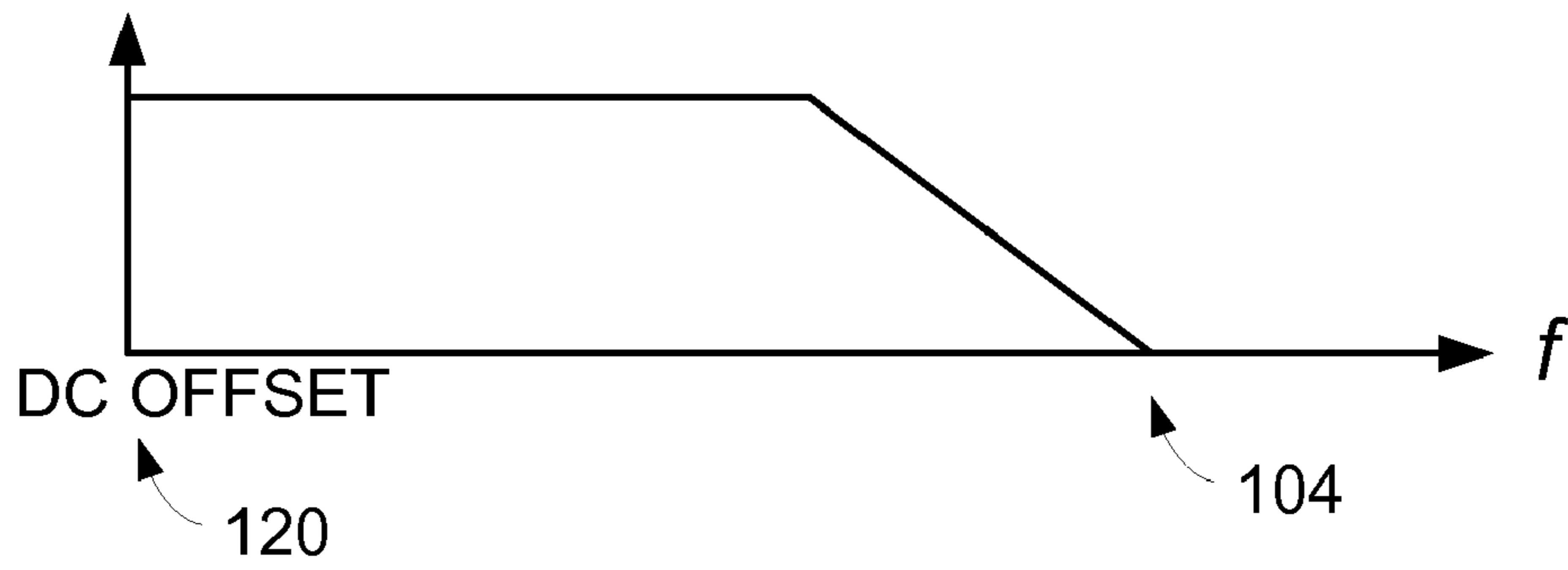


FIG. 1C

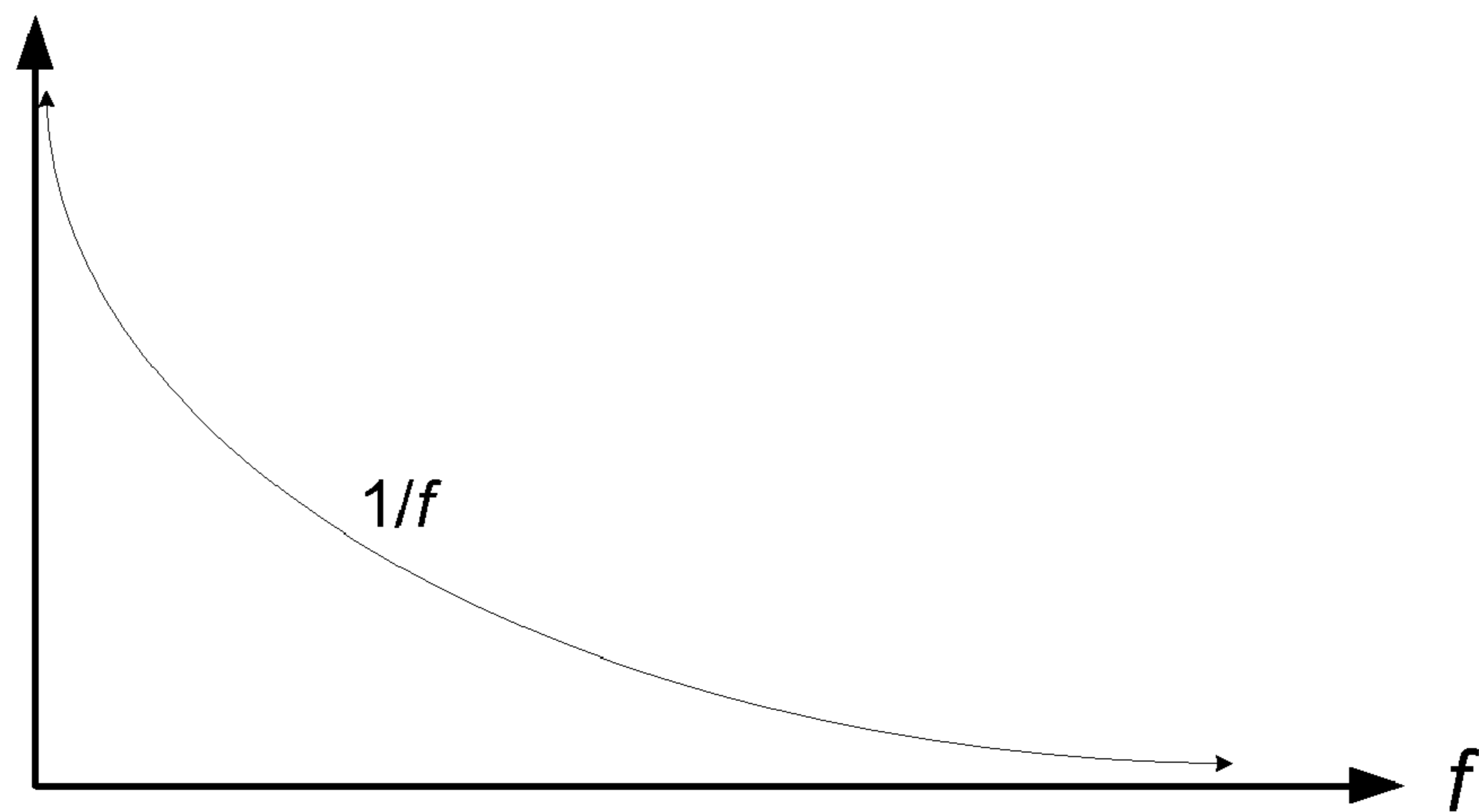


FIG. 1D

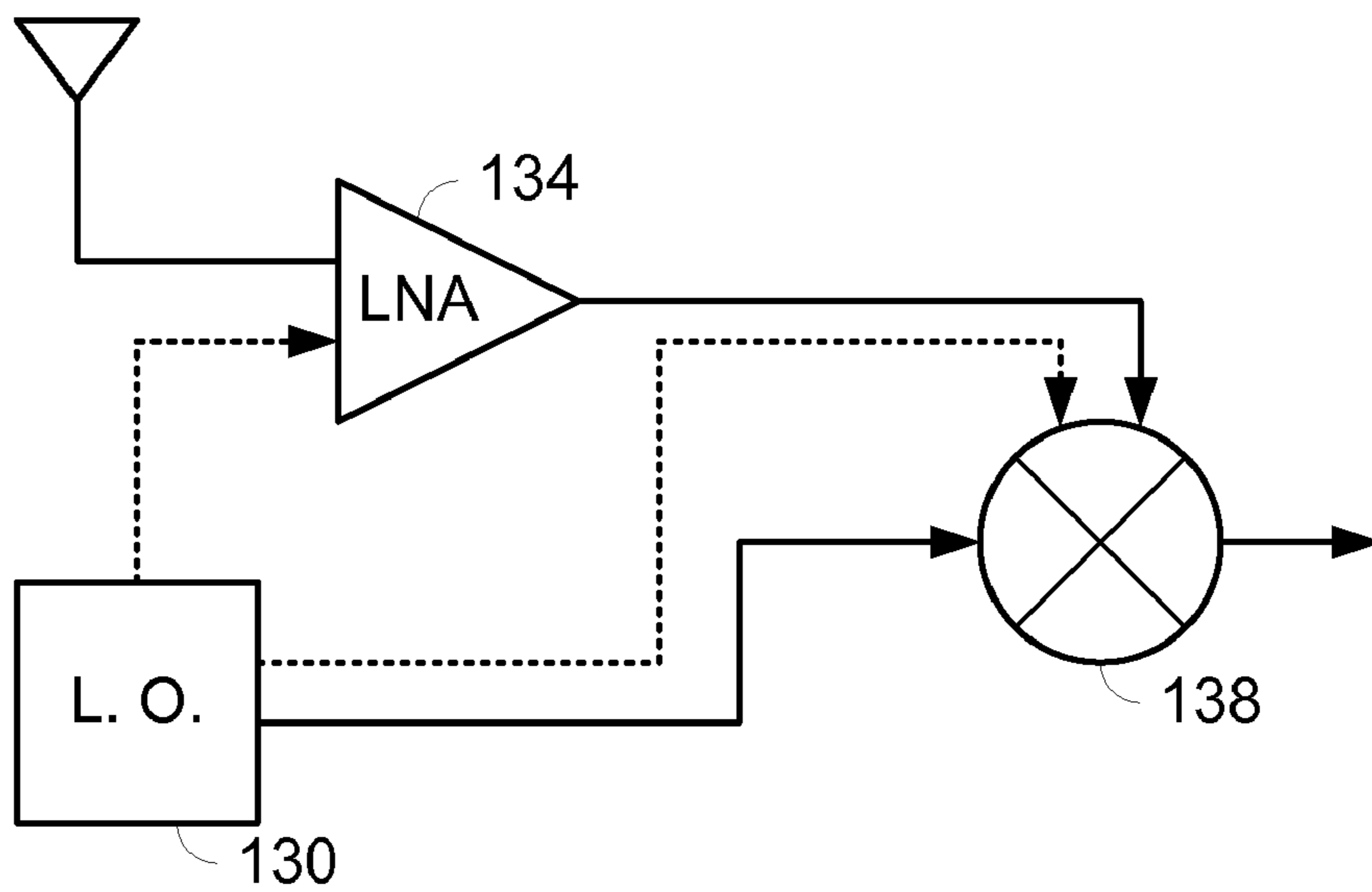


FIG. 1E

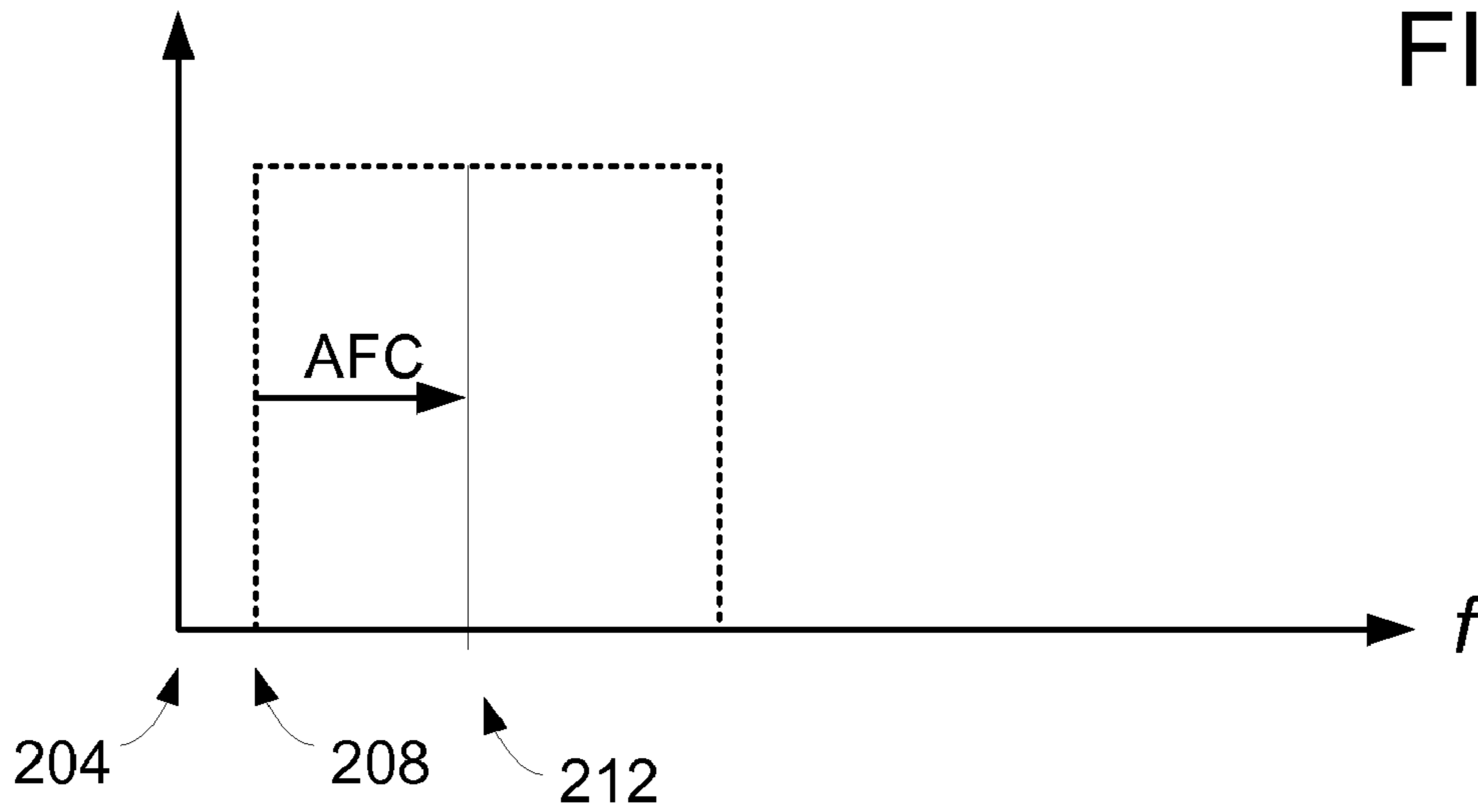


FIG. 2A

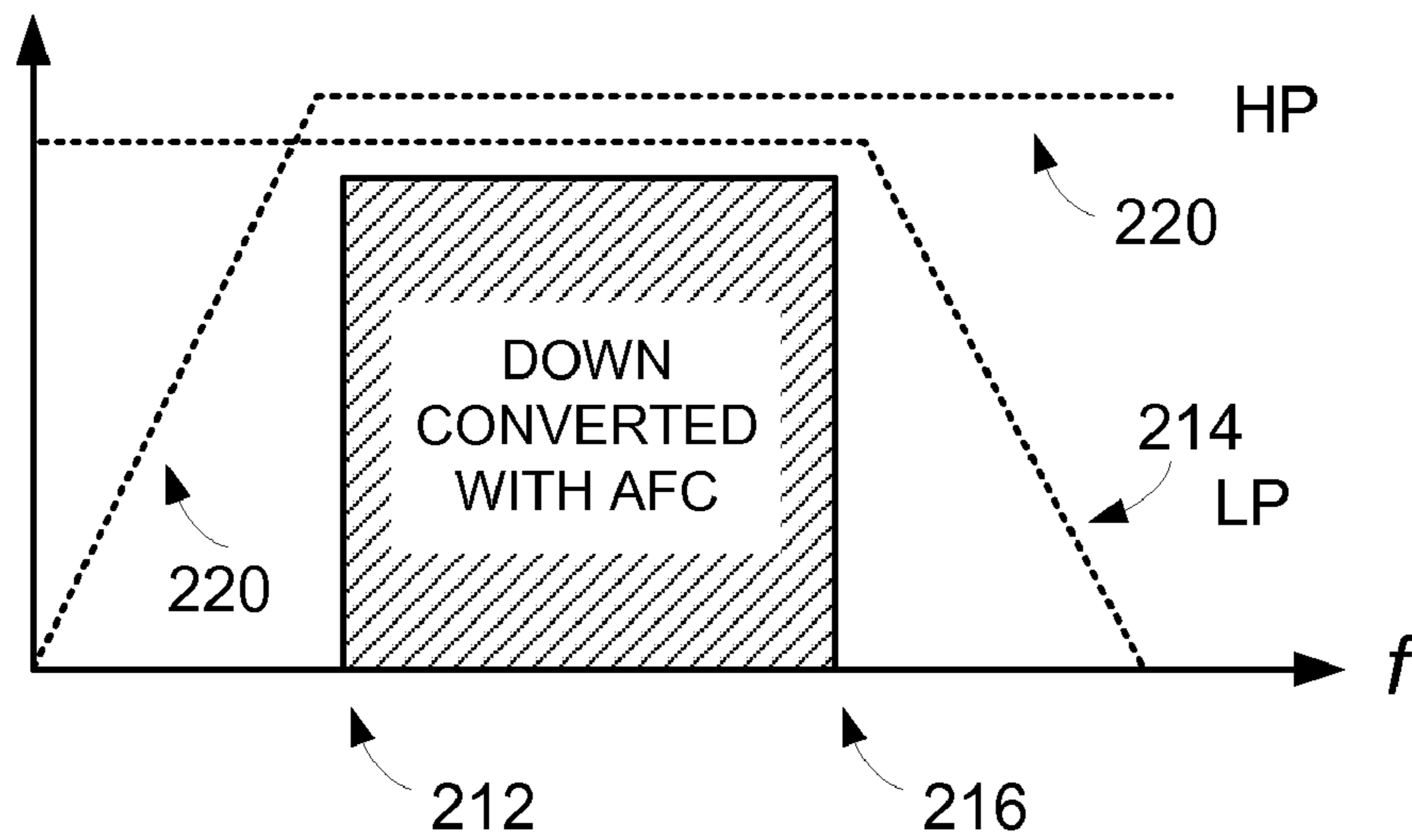


FIG. 2B

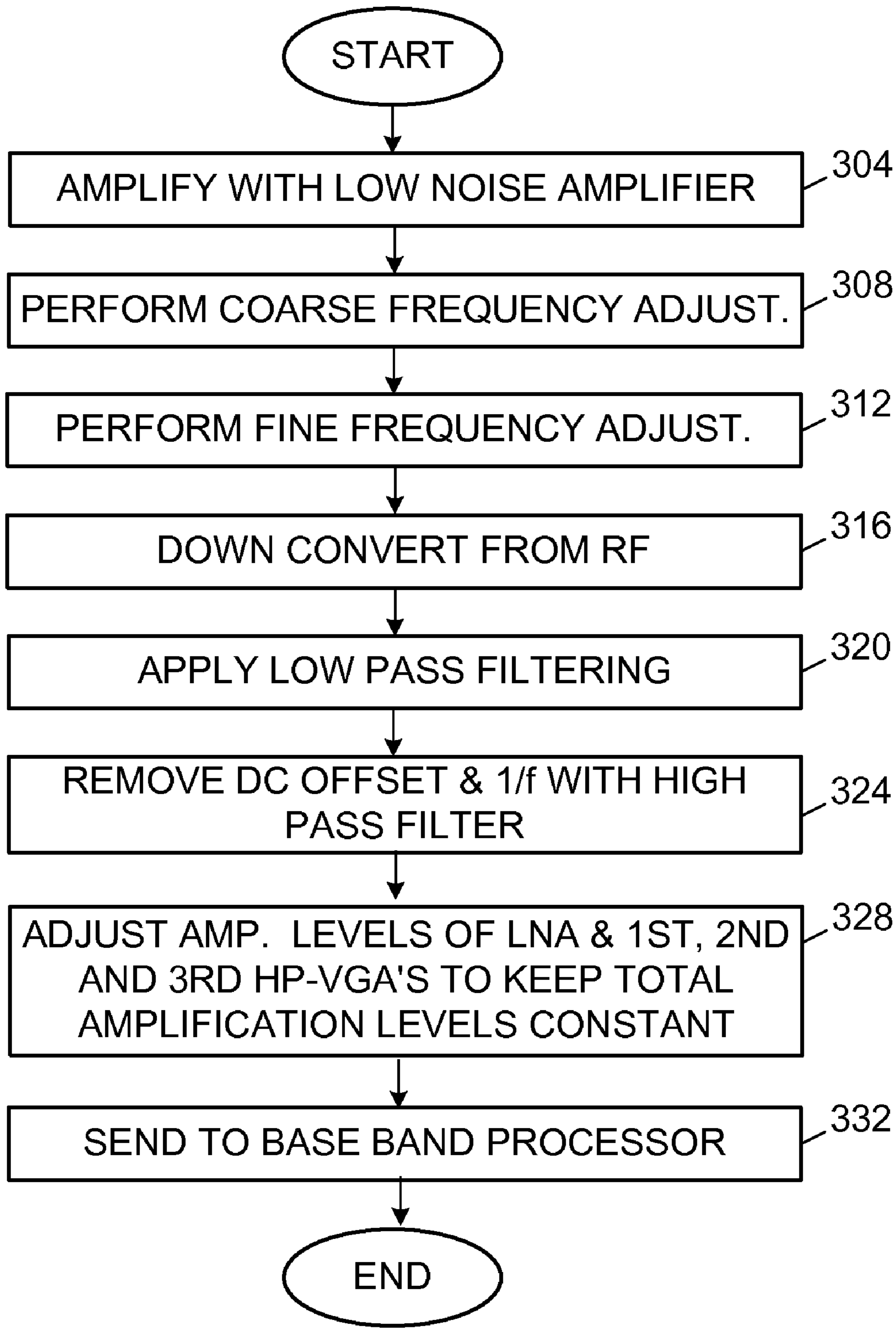


FIG. 3

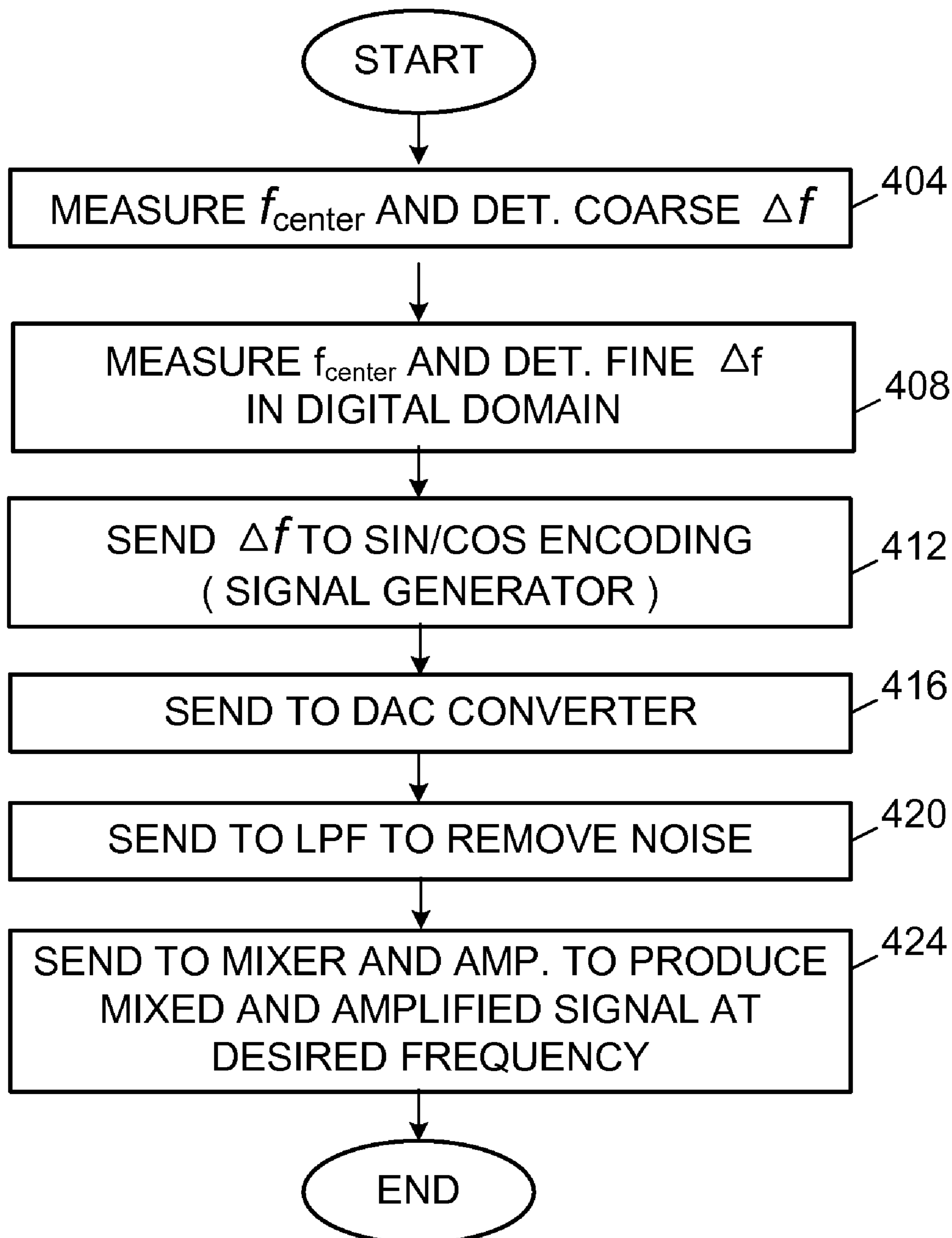


FIG. 4

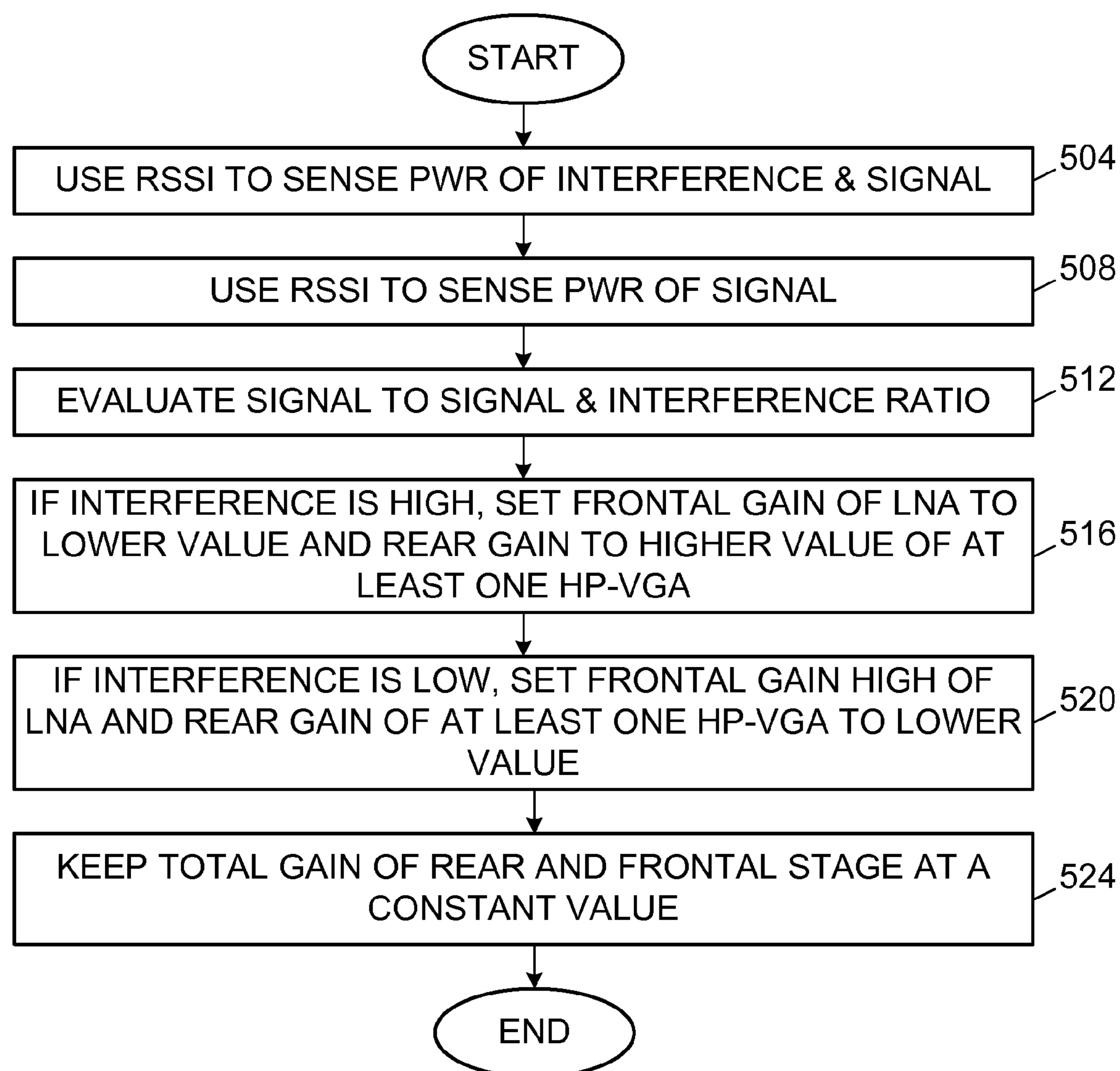


FIG. 5

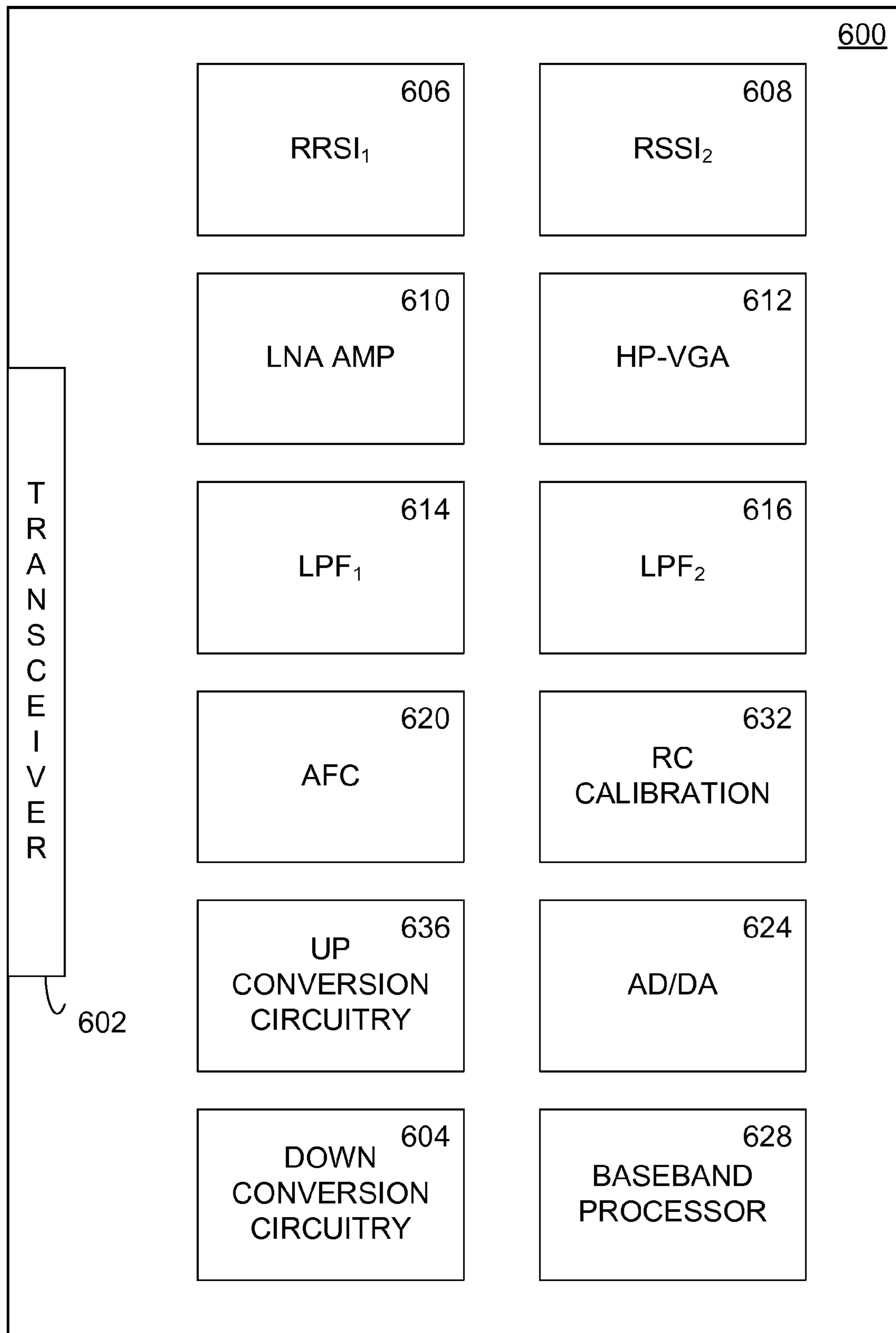


FIG. 6

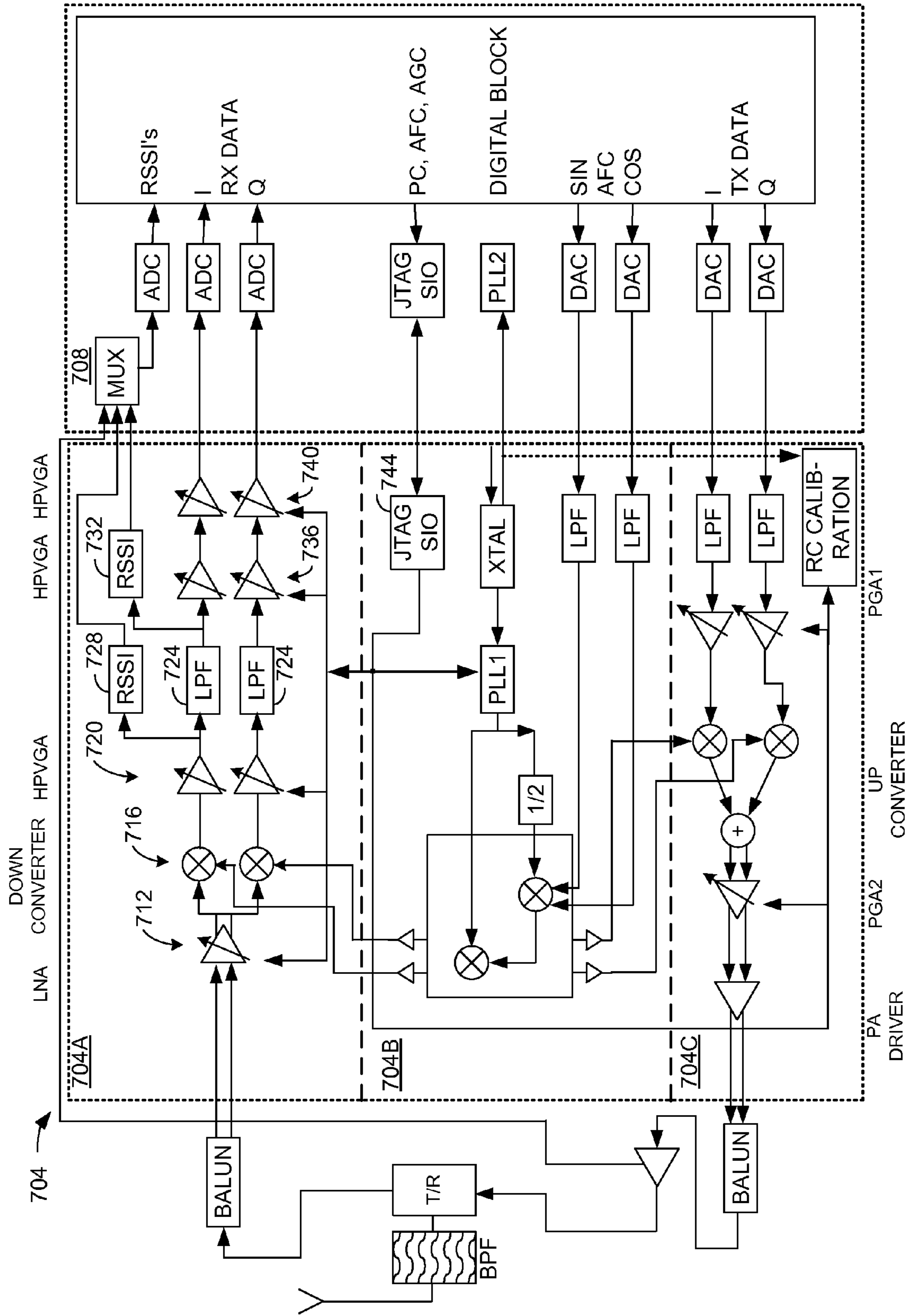


FIG. 7



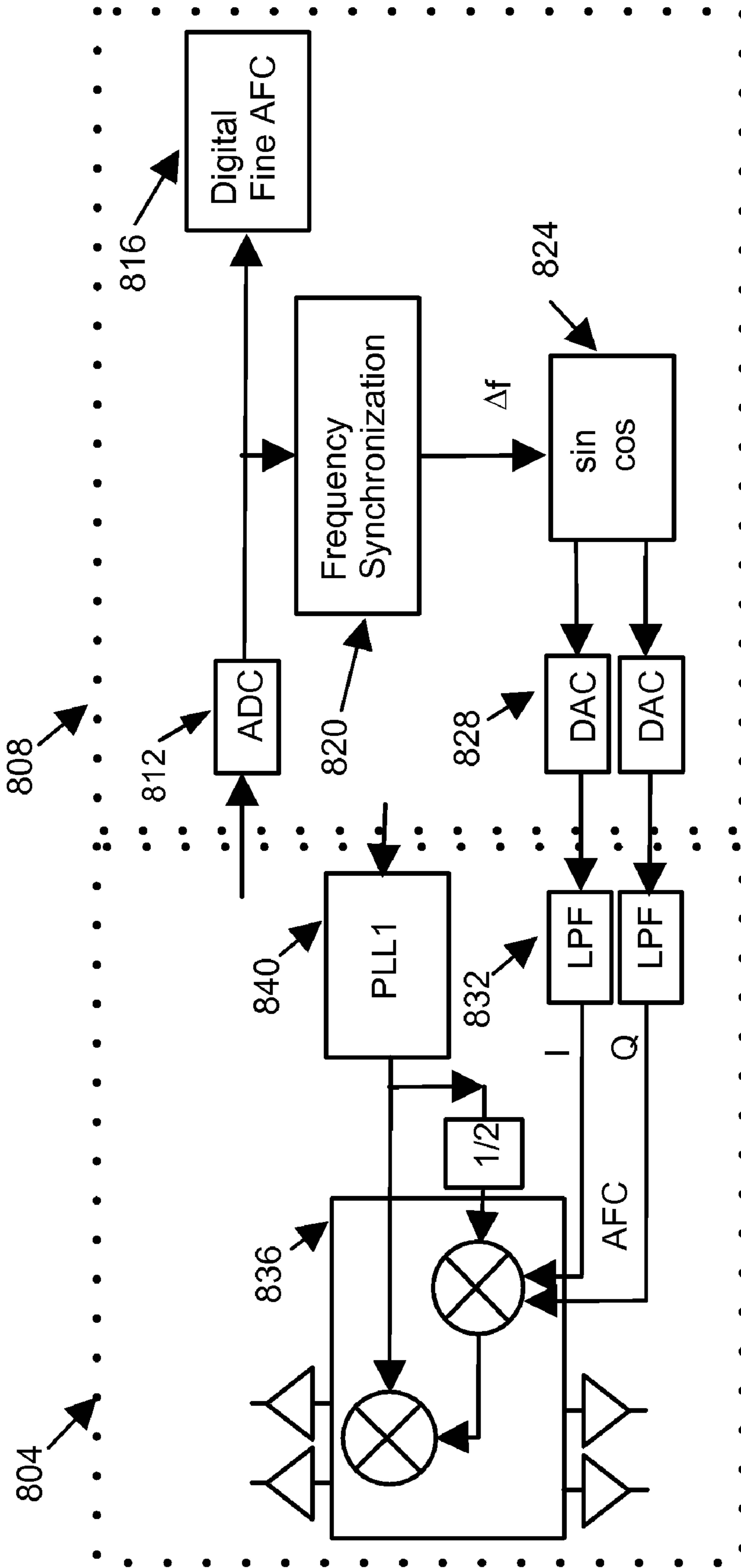


FIG. 8

## DIRECT CONVERSION RF TRANSCEIVER FOR WIRELESS COMMUNICATIONS

### CROSS-REFERENCE TO RELATED APPLICATIONS

The present U.S. Utility Patent Application claims priority pursuant to 35 U.S.C. §120, as a continuation, to the following U.S. Utility Patent Application which is hereby incorporated herein by reference in its entirety and made part of the present U.S. Utility Patent Application for all purposes:

1. U.S. Utility application Ser. No. 11/743,143, entitled "A Direct Conversion RF Transceiver for Wireless Communications," filed May 1, 2007, pending, which claims priority pursuant to 35 U.S.C. §120, as a continuation, to the following U.S. Utility Patent Application which is hereby incorporated herein by reference in its entirety and made part of the present U.S. Utility Patent Application for all purposes:
  - a. U.S. Utility application Ser. No. 10/052,870, entitled "A Direct Conversion RF Transceiver for Wireless Communications," filed Jan. 18, 2002, now U.S. Pat. No. 7,212,586.

### BACKGROUND

#### 1. Technical Field

The present invention relates to wireless communications and, more particularly, wideband wireless communication systems.

#### 2. Related Art

Super-heterodyne receivers traditionally receive an RF signal that must be converted to base band by way of an intermediate frequency (IF). Thereafter, the IF signal is amplified and filtered to define a communication channel. In a transmitter, similarly, a base band signal is up converted to the intermediate frequency wherein the amplification and subsequent filtering are carried out at the IF stages. While some systems skip the IF conversion step, wideband systems typically require conversion to IF stages. Depending on the signal bandwidth and the type of communication system, semiconductor devices are not yet able to allow full integration of active filters operating at the elevated intermediate frequencies for a wideband or high data rate communication network. To carry out filtering at the intermediate frequencies, surface acoustic wave filters (SAW) are commonly used. The SAW filters have the drawback, however, of being bulky, heavy and expensive. Additionally, the SAW filters require low impedance matching thereby resulting in high power consumption. Because they are often powered by battery, portable wireless communication devices are not readily adaptable for such systems in that they are required to be inexpensive, light and consume lower amounts of power. Thus, there is a need to design transceiver systems that eliminate the use of intermediate frequency filters.

An alternate approach to using a higher intermediate frequency that requires the SAW filters is to convert the RF signal to an intermediate frequency that is sufficiently low to allow the integration of on-chip channel selection filters. For example, some narrow band or low data rate systems, such as Bluetooth, use this low intermediate frequency design approach.

One problem using low intermediate frequencies, however, is satisfying image rejection requirements for the systems. The image rejection requirement for the down conversion is hard to meet and is usually limited to about -40 dB. Thus, this low intermediate frequency approach is limited for narrow

band or low data rate systems. Wide band or high data rate systems require an intermediate frequency that is not low enough for the integration of channel selection filters given the technology that is available today for semiconductor processes. There is a need, therefore, for a wireless transceiver system that allows for full integration on-chip of circuit designs that support high data rate and wideband communications.

### SUMMARY OF THE INVENTION

The present invention is directed to apparatus and methods of operation that are further described in the following Brief Description of the Drawings, the Detailed Description of the Invention, and the claims. Other features and advantages of the present invention will become apparent from the following detailed description of the invention made with reference to the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered with the following drawings, in which:

FIGS. 1A, 1B, 1C and 1D are frequency response curves and FIG. 1E is a block diagram that illustrate some of the challenges that exist for developing zero IF systems that are all integrated within a semiconductor device;

FIGS. 2A and 2B illustrate frequency response curves that are realized by the present inventive system or transceiver;

FIG. 3 is a flowchart illustrating an overall method performed by the inventive transceiver according to one embodiment of the present invention;

FIG. 4 is a flowchart that illustrates a method for adjusting the channel frequency to a desired channel frequency according to one embodiment of the present invention;

FIG. 5 is a flowchart that illustrates a method for amplifying a received signal in a transceiver according to one embodiment of the present invention;

FIG. 6 is a functional block diagram of a transceiver formed according to one embodiment of the present invention;

FIG. 7 is a functional schematic diagram of a transceiver formed according to one embodiment of the present invention; and

FIG. 8 is a functional schematic diagram of an automatic frequency control (AFC) circuit formed according to one described embodiment of the invention.

### DETAILED DESCRIPTION OF THE DRAWINGS

Generally, the present invention provides a transceiver that allows for wideband systems formed on a chip that allow for up and down converting from base band and radio frequency without conversion to an intermediate frequency (zero IF).

FIGS. 1A, 1B, 1C and 1D are frequency response curves that illustrate some of the challenges that exist for developing zero IF systems that are all integrated within a semiconductor device. Referring now to FIG. 1A, a signal is transmitted over a wireless medium as an RF signal shown generally at **104**. For processing by a receiver, however, that signal is first down converted to an intermediate frequency (IF) shown generally at **108**, wherein some preliminary processing occurs. Thereafter, the signal is down converted from intermediate frequency **108** to base band frequency **112**.

The foregoing discussion about SAW filters may be considered in view of the frequency shown generally at **116**. If the intermediate frequency is low enough, then the filters may be developed on chip. As described previously, however, the image rejection of the on chip filters is not always satisfactory. Thus, it is desirable to develop a zero IF system, meaning that no intermediate frequencies are used, as is illustrated in FIG. **1B**, in order to satisfy image rejection requirements. Accordingly, received signals are transmitted directly from the RF signal **104** to the base band frequency **112** as is shown in FIG. **1B**. Similarly, signals that are to be transmitted are up converted from base band frequency **112** to RF signal **104**.

One problem with down converting signals directly from RF signal **104** to base band frequency **112** is that the process of down converting the signal immediately results in a DC offset **120**, as is shown in FIG. **1C**. Additionally, a noise component, often described as a  $1/f$  interference, is illustrated in FIG. **1D**. As may be seen, the  $1/f$  interference is very high at low frequencies but tapers off as the frequency is increased. One problem with the DC offset and the  $1/f$  interference is that any amplification of the received signal includes amplification of interference and/or DC power from the DC offset thereby saturating the amplifier with signals other than the received or target signal.

FIG. **1E** further illustrates the process that generates most of the DC offset. For example, a local oscillator (LO) **130** often produces leakage current that is conducted into the input of an amplifier or a mixer. More specifically, as may be seen in FIG. **1E**, a local oscillator **130** has leakage current that is conducted into the input of low noise amplifier (LNA) **134** and the input of mixer **138**. This type of self mixing produces the most of DC offset at the output of the mixer **138**. It is very important, therefore, to eliminate these leakage currents so that the DC offset is at a minimum level.

FIGS. **2A** and **2B** illustrate frequency response curves that are realized by the present inventive system or transceiver. Referring now to FIG. **2A**, a DC offset is shown at **204**, while the low end of a received signal frequency is shown at **208**. FIG. **2B** illustrates a high pass (HP) filter **220** that eliminates the DC-offset **204** and a low pass (LP) filter **214** that selects the desired signal channel by attenuating higher frequency interference. In reality, with limited accuracy of local oscillation frequency due to cheap reference crystal is used, if received signal could be down converted too low that it could be attenuated by the HP filter **220**. And it could be down converted too high that is could be attenuated by the LP filter **214**. In order to avoid signal degradation, automatic frequency control (AFC) is proposed as show in FIG. **2A**. Accordingly, the invention includes a transceiver that determines the difference between frequency **208** and ideal frequency **212** (as shown in FIG. **2B**) and adjusts LO frequency so that the low end of the received signal is located at **212** and the high end of the signal is located at **216**.

FIG. **2B** illustrates that the down converted signal after LO frequency correction is located in the desired frequency range, wherein the low end of the frequency is at **212** and the high end is at **216**. As may be seen, the channel for the received signal now ranges from the frequency shown at **212** to the frequency shown at **216**. Moreover, FIG. **2B** shows a high pass filter frequency response curve **220**. As may be seen, the channel of the received signal is well beyond the attenuation part of HP filter curve **220**. Without adjusting the frequency of LO, the high pass filter, whose frequency response curve is shown in FIG. **2B**, would have filtered or eliminated some of the received signal thereby losing information. Thus, FIGS. **2A** and **2B** suggest that the inventive system includes circuitry for not only correcting LO fre-

quency, but also to filter the received signal thereafter with a high pass filter and a low pass filter.

FIG. **3** is a flowchart that illustrates an overall method performed by the inventive transceiver according to one embodiment of the present invention. Referring now to FIG. **3**, a first process step taken by the transceiver is to amplify a received RF signal with a low noise amplifier (step **304**). Thereafter, the frequency of the received signal is adjusted by LO frequency with an automatic frequency control circuitry. In the described embodiment, a coarse adjustment is made (step **308**), as well as a fine adjustment that is made in the digital domain (step **312**). Thereafter, the signal is down converted from a specified RF channel to a specified base band channel (step **316**) and a low pass filter is applied to eliminate interference occurring above the channel (step **320**). Thereafter, a DC offset and low frequency interference (e.g.,  $1/f$ ) is removed with at least one high pass filter tuned to pass the base band channel (step **324**). Finally, the signals are amplified by a plurality of amplifiers. The amplification level of the amplifiers is adjusted in an inverse proportional manner according to interference levels so that total amplification remains constant (step **328**).

FIG. **4** is a flowchart that illustrates a method for adjusting the channel frequency to a desired channel frequency according to one embodiment of the present invention. Referring now to FIG. **4**, the inventive method includes initially measuring a center frequency for the received RF signal and determining the difference between that center frequency and the center frequency of a specified RF channel (step **404**). Initially, a coarse difference is measured and is corrected by adjusting LO frequency. Then, the residual difference is adjusted to a fine degree of measurement in the digital domain to obtain an accurate difference between an actual center frequency and a specified center frequency (step **408**). The difference in center frequencies is then transmitted to a signal generator (step **412**). In the described embodiment of the invention, the signal generator for the transceiver is one that is capable of performing quadrature phase shift keyed modulation of signals. Accordingly, the difference in center frequency values determined in step **404** is transmitted to a sine and a cosine element of an encoder or signal generator.

After the difference in frequency has been sent to the sine/cosine encoders, the signals are transmitted from the encoders to a digital-to-analog converter (step **416**). Thereafter, the digital-to-analog converter transmits the signals to a low pass filter to remove high frequency interference (step **420**). Thereafter, the signal is transmitted to a mixer to produce a new local oscillator signal output. The new local oscillator output signal is characterized by the desired frequency channel (step **424**).

FIG. **5** is a flowchart that illustrates a method for amplifying a received signal in a transceiver according to one embodiment of the present invention. The method of FIG. **5** generally includes using a plurality of received signal strength indicators (RSSI) to sense the power of the received interference and signal to determine a right amplification of cascaded amplifier stages. Initially, a first RSSI is used to sense the power of the received interference and signal (step **504**). Thereafter, a second RSSI is used to sense the power of the signal without the interference (step **508**). After measuring the power of the signal, as well as the power of the interference and signal, the transceiver evaluates the ratio of signal power to signal and interference power to determine optimal amplification techniques by each of a plurality of amplifiers (step **512**). If the interference level is high, the gain of a first amplifier is set to a lower value and the rear gain of a second amplifier, which is located after channel selection

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filter, is set to a higher value in a multi-amplifier system (step 516). If the interference value is relatively low, the frontal gain is set to a higher value and the rear gain is set to a lower value (step 520). As the gain of the frontal and rear amplifiers are adjusted, they are adjusted in a manner wherein the total amplification is kept at a constant level required for certain power level of desired channel or signal (step 524). In the described embodiment, an LNA is used for the front end and three high pass variable gain amplifiers (HP-VGA's) are used in subsequent stages.

FIG. 6 is a functional block diagram of a transceiver formed according to one embodiment of the present invention. Referring now to FIG. 6, a transceiver 600 includes a transceiver port 602 for receiving and transmitting communication signals. In the described embodiment of the invention, transceiver port 602 receives signals transmitted at the RF and generates signals that are transmitted externally at the RF.

In addition to transceiver port 602, transceiver 600 further includes a plurality of RSSIs 606 and 608 that are for sensing the power level of the received signals and, more particularly, of the received signal as well as the received signal and interference. Transceiver 600 further includes a pair of low pass filters 614 and 616 and an automatic frequency control (AFC) circuit 620. Automatic frequency control 620 is for adjusting the LO frequency in the zero IF transceiver 600 to align with the desired frequency channel. In the described embodiment, AFC 620 adjusts the frequency of the LO frequency so that the received signal is located within the unattenuated part of HP and LP filters. Transceiver 600 further comprises an A-D and D-A conversion circuitry 624 that is for converting signal formats as required. Additionally, transceiver 600 includes a base band processor 628 that is for processing the received signal and the signal to transmit. Transceiver 600 further includes up conversion circuitry 636 that receives signals that are to be transmitted at base band from base band processor 628 and then up converts the base band signals to the RF for transmission from transceiver port 602. Finally, transceiver 600 includes down conversion circuitry 604 for converting a received RF signal to base band frequencies.

In operation, transceiver port 602 receives RF signals and converts the signals from the RF to base band. The down conversion is performed by down conversion circuitry 604 of FIG. 6. Once the signal has been down converted, the RSSI filters 606 and 608 sense the power of the signal, as well as the signal plus interference, to determine the manner in which the amplification stages should be set for the received signal. While transceiver 600 shows a pair of low pass filters 614 and 616 which are used as a part of filtering higher frequency interference during the down conversion process as well as during the automatic frequency control or adjustment process by AFC 620, it is understood that transceiver 600 may include more than or less than two low pass filters. In general, low pass filters 614 and 616 represent the low pass filtering that occurs during the down-conversion process as well as during the automatic frequency control process to adjust the frequency of the received signals. Thus, in addition to sensing the power levels of the signal and interference of the received signal, the frequency is adjusted by AFC 620 at which time it is filtered by high pass filter to remove DC offset and the 1/f interference. After the low frequency interference has been removed, as well as the high frequency interference from the various filters, the signal is amplified and converted into digital domain for processing by the base band processor. The signal is amplified by LNA amp 610 and HP-VGA amps 612, whose total amplification is kept at a constant value (for a

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certain power level of received signal) but whose individual amplification is either increased or decreased according to the signal and signal plus interference ratios described earlier.

FIG. 7 is a functional schematic diagram of a transceiver formed according to one embodiment of the present invention. Referring now to FIG. 7, a transceiver system comprises radio circuitry 704 that is coupled to base band processing circuitry 708. The radio circuitry 704 performs filtering, amplification, frequency calibration (in part) and frequency conversion (down from the RF to base band and up from base band to the RF). Base band circuitry 708 performs the traditional digital signal processing in addition to partially performing the automatic frequency control. As may be seen, the single chip radio circuitry 704 is coupled to receive radio signals that are initially received by a transceiver and then converted by a Balun signal converter which performs single end to differential conversion for the receiver (and differential to single end conversion for the transmitter end). The Balun are shown to be off chip in FIG. 7, but they may be formed on chip with radio circuitry 704 as well.

More specifically, radio circuitry 704, and more particularly, portion 704A, includes a low noise amplifier 712 that is coupled to receive the RF from a transceiver port. The low noise amplifier 712 then produces an amplified signal to a mixer 716 that is for adjusting and mixing the RF as a part of the automatic frequency control that is performed by the radio and base band circuits 704 and 708. The outputs of the mixer (I and Q of a quadrature phase shift keyed signals) are then produced to a first HP-VGA stage 720.

The outputs of the first HP-VGA stage 720 are then produced to a first RSSI 728 as well as to a low pass filter stage 724. The outputs of the low pass filter stage 724 are then produced to a second RSSI 732, as well as to a second HP-VGA 736 and third HP-VGA 740 as may be seen in FIG. 7.

In operation, the first RSSI measures the power level of the signal and interference. The second RSSI measures the power level of the signal only. The base band processing circuitry 708 then determines the ratio of the RSSI measured power levels to determine the relative gain level adjustments of the front and rear stage amplification stages. In the described embodiment of the invention, if the power level of the signal and interference is approximately equal to or slightly greater than the power level of the signal alone, then the first amplification stages are set to a high value and the second amplification stages are set to a low value.

Conversely, if the power level of the signal and interference is significantly greater than the power of the signal alone, thereby indicating significant interference levels, the first amplification stages are lowered and the second amplification stages are increased proportionately.

Automatic frequency control circuit 704B includes low pass filters for filtering I and Q signals and mixer circuitry for actually adjusting LO frequency. The operation of mixers and phase locked loop for adjusting frequencies is known. Circuit 704B further includes JTAG (Joint Test Action Group, IEEE1149.1 boundary-scan standard) serial interface (SIO) circuitry 744 for transmitting control signals and information to circuit portions 704A (e.g., to control amplification levels) and to portion 704B (e.g., to control or specify the desired frequency for the automatic frequency control).

A portion of the automatic frequency control circuitry that determines the difference in frequency between a specified center channel frequency and an actual center channel frequency for a received RF signal is formed within the base band circuitry in the described embodiment of the invention. This portion of the circuitry includes circuitry that coarsely

measures the frequency difference and then uses measures the frequency difference in the digital domain to obtain a more precise measurement.

Finally, radio circuitry portion **704C** includes low pass filtration circuitry for removing any interference that is present after base band processing as well as amplification, mixer and up converter circuitry for preparing a base band signal for transmission at the RF.

FIG. **8** is a functional schematic diagram of an automatic frequency control (AFC) circuit formed according to one described embodiment of the invention. The AFC circuit of FIG. **8** comprises a RF signal processing portion **804** and a base band signal processing portion **808**. Generally, portion **804** is for adjusting LO frequency. Portion **808** is for determining the difference in center channel frequencies between the received RF and the expected frequency value for the received signal.

Analog-to-digital converters (ADC) **812** are used to convert the received analog signal into digital. ADC **812** is coupled to provide the received RF signal in a digital format to a frequency synchronization circuitry **820** that measures the frequency difference in a coarse degree of resolution. Digital frequency control circuitry **816** performs its measurements and calibration in the digital domain and provides its results to frequency synchronization circuitry **820** to adjust the frequency difference of frequency synchronization circuit **820** with a fine degree of resolution.

Frequency synchronization circuit **820**, as a part of determining the difference in center channel frequency for the received signal and an expected value, receives and interprets a pilot signal that defines the expected center channel frequency. Accordingly, after measuring the actual center channel frequency of the received RF, frequency synchronization circuit **820** is able to determine the frequency difference. Frequency synchronization circuit **820** then produces a signal defining the difference in center channel frequency for the received signal and an expected value to signal generator **824**. It is understood that the pilot channel is transmitted as a part of standard wireless network communication protocols for signal control and synchronization purposes.

Signal generator **824**, upon receiving the difference in center channel frequency for the received signal and an expected value, produces quadrature phase shift keyed (I & Q) outputs for the received frequency difference to a pair of digital to analog converters (DAC) **828**. The analog outputs of DAC **828** are then passed to low pass filters **832** and are then up converted back to the RF. The I and Q RF signal components are then produced to mixer circuitry **836** that also receives a specified input from phase locked loop circuitry **840** to produce a received RF having a specified center channel frequency. It is understood that mixer circuitry **836** (including PLL circuitry **840**) further receives control signals from base band processing circuitry (not shown in FIG. **8**) specifying the expected center channel frequency that is specified in the aforementioned pilot channel.

While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and detailed description. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but, on the

contrary, the invention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the claims. As may be seen, the described embodiments may be modified in many different ways without departing from the scope or teachings of the invention.

The invention claimed is:

**1.** A transceiver, comprising:

a transceiver port comprising an antenna for receiving and transmitting wireless communication signals at radio frequency;

a receive path coupled to receive ingoing radio frequency (RF) signals from the transceiver port and coupled to produce ingoing digital signals to a transceiver processor;

down conversion circuitry disposed within the receive path and coupled to receive the ingoing RF signals wherein the down conversion circuitry produces down-converted communication signals based on the received ingoing RF signals;

automatic frequency control circuit that comprises:

an RF signal processing portion that supports down converting ingoing signals from RF and up-converting outgoing signals to RF;

a first frequency oscillation block generates a local oscillation based upon a frequency specified in a received pilot signal;

a first mixing element that mixes a divided oscillation based upon the local oscillation and an oscillation correction signal;

a frequency correction block that generates the oscillation correction signal having an oscillating signal form for adjusting a frequency of the divided local oscillation, wherein the oscillation correction signal is based on a difference between a center frequency of the ingoing RF signals and an expected center frequency of the ingoing RF signals;

a plurality of amplifiers operably disposed within the receive path including a low noise amplifier operably disposed in the receive path between the transceiver port and the down conversion circuitry;

received signal strength indication circuitry for measuring signal and interference power levels from a first node and for measuring signal power levels from a second node; and

wherein the transceiver:

determines a ratio of the signal power level in relation to the signal and interference power level; and

reciprocally adjusts a low noise amplifier gain setting and a gain setting of at least one other amplifier of the plurality of amplifiers operably disposed within the receive path to maintain a constant total gain in the receive path based upon the determined ratio.

**2.** The transceiver of claim **1** further including:

low pass filtering circuitry; and

wherein the received signal strength indication circuitry further includes:

first received signal strength indication circuit for measuring power levels of signal and interference from the first node wherein the first node is disposed in the receive path downstream of the down conversion circuitry and up-stream of the low pass filtering circuitry; and

second received signal strength indication circuit for measuring signal power levels from a node disposed down-stream of the low pass filtering circuitry.

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3. The transceiver of claim 1 wherein:  
the plurality of amplifiers operably disposed within the  
receive path includes variable gain amplification cir-  
cuitry disposed downstream of the low pass filtering  
circuitry.

4. The transceiver of claim 3 wherein the variable gain  
amplification circuitry includes at least one high-pass vari-  
able gain amplification circuit that high pass filters and ampli-  
fies received down-converted communication signals.

5. The transceiver of claim 1 wherein the down conversion  
circuitry produces quadrature phase shift keyed down-con-  
verted communication signals.

6. The transceiver of claim 5 wherein the phase shift keyed  
down-converted communication signals comprise in-phase  
and quadrature phase signal components.

7. The transceiver of claim 1 further including circuitry for  
adjusting a local oscillation frequency coupled to the trans-  
ceiver port and operable to adjust the local oscillation fre-  
quency to a desired RF channel for the in-phase and quadra-  
ture phase signal components.

8. The transceiver of claim 1 wherein the transceiver:  
produces the local oscillation using a phase-locked loop  
circuit;

produces a digital oscillation correction signal and con-  
verts the oscillation correction signal to an analog signal  
to produce the oscillation correction signal;

adjusts the local oscillation produced by the phase-locked  
loop circuit based on the oscillation correction signal;  
and

wherein the oscillation correction signal produces a fine  
frequency adjustment to the local oscillation in addition  
to frequency adjustments made by the phase-locked  
loop.

9. A transceiver, comprising;

a transceiver port comprising an antenna for receiving and  
transmitting radio frequency communication signals  
wherein received signals are processed in a receive cir-  
cuit path;

automatic frequency control circuitry for producing an  
adjusted local oscillation frequency (LO);

mixing circuitry for down converting the received radio  
frequency (RF) signal based upon an LO that is further  
based upon a receive pilot signal and upon the adjusted  
LO;

received signal strength indication circuitry for measuring  
power levels of signal and interference from a plurality  
of nodes disposed within the receive circuit path;

a plurality of amplifiers operably disposed within the  
receive circuit path;

wherein the transceiver adjusts relative power levels of the  
plurality of amplifiers operably disposed within the  
receive circuit path to maintain a constant total amplifi-  
cation based upon measured power levels of signal and  
interference; and

wherein automatic frequency control circuitry comprises:  
phase locked loop circuitry that generates a coarsely  
tuned local oscillation frequency in an analog portion  
of the receive circuit path based upon a frequency  
specified within a pilot signal;

digital frequency correction logic that generates a digital  
local oscillation correction signal based on a received  
signal produced by the analog portion of the receive  
circuit path; and

wherein the automatic frequency control circuitry gener-  
ates a finely tuned local oscillation frequency in an  
analog portion having an oscillating signal form of the

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receive circuit path based on the digital local oscilla-  
tion correction signal and on the coarsely tuned local  
oscillation.

10. The transceiver of claim 9 further including a low pass  
filter disposed within the analog portion of the receive circuit  
path wherein:

the low pass filter blocks interference;

a first received signal indicator circuit measures received  
signal and interference power from a first node disposed  
upstream of the low pass filter; and

a second received signal indicator circuit measures  
received signal power from a first node disposed down-  
stream of the low pass filter.

11. The transceiver of claim 9 wherein one of the plurality  
of amplifiers comprises first high pass variable gain amplifi-  
cation circuitry operably disposed downstream of the low  
pass filtering circuitry.

12. The transceiver of claim 11 wherein one of the plurality  
of amplifiers comprises a second high pass variable gain  
amplifier circuit operably disposed downstream of the first  
high pass variable gain amplification circuitry.

13. The transceiver of claim 10 further including high pass  
filter circuitry disposed upstream of the low pass filter for  
removing at least one of a DC offset and low frequency  
interference and signal components.

14. The transceiver of claim 9 wherein the automatic fre-  
quency control circuitry generates in-phase and quadrature  
phase local oscillation frequency components to support  
down conversion of quadrature phase shift keyed radio fre-  
quency signals.

15. The transceiver of claim 8 further including an up  
converter for up converting base band signals to radio fre-  
quency signals for transmission from the transceiver port  
based on the finely tuned local oscillation frequency.

16. A method in a high data rate communication transceiver  
comprising:

receiving and amplifying wideband or high data rate radio  
frequency (RF) communication signals in a receive cir-  
cuit path of the transceiver;

generating a local oscillation (LO) based upon a frequency  
specified by a received pilot signal;

generating a frequency corrected LO;

mixing with frequency corrected LO with the LO to create  
an adjusted LO;

down converting the received signals from RF to a lower  
frequency based upon the adjusted LO;

producing a digital ingoing signal to a processing block;

adjusting the LO with a correction signal;

down converting the received RF communication signals  
with the adjusted LO to produce ingoing communication  
signals;

determining a difference between an expected center chan-  
nel frequency and a received center channel frequency;

based on the determined difference, generating a frequency  
correction input having an oscillating signal form to  
adjust a local oscillation frequency to adjust a center  
frequency of a down converted signal;

measuring power levels of the ingoing communication sig-  
nals at a plurality of nodes disposed within a receive  
circuit path; and

adjusting amplification levels in the receive circuit path  
based upon the measured power levels.

17. The method of claim 16 further including:

measuring power levels of signal and interference of the  
down converted received signals from a first node dis-  
posed up-stream of low pass filtering circuitry; and

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measuring power levels of the down converted received signals from a second node disposed down-stream of the low pass filtering circuitry.

**18.** The method of claim **17** wherein the amplification levels are adjusted to maintain a constant amount of total amplification in the receive circuit path.

**19.** The method of claim **17** further including receiving a pilot signal and determining an expected center channel frequency based on the received pilot signal and determining a

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frequency difference between the received RF frequency and the expected center channel frequency wherein the correction signal is based on the frequency difference.

**20.** The method of claim **19** wherein the frequency difference is determined by measuring an actual center frequency of the received signals and comparing the measured center frequency to the center channel frequency information of the pilot signal.

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